FISH MEALS AND OILS

FEEDING VALUE FOR LIVE STOCK AND POULTRY

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CENTRAL EXPERIMENTAL FARM, OTTAWA

DOMINION EXPERIMENTAL FARMS
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The Dominion Experimental Farms, in response to inquiries, have conducted a series of experiments for the purpose of ascertaining the feeding value of fish products for live stock and poultry. These experiments compared fish meal and fish oils with other supplemental feeds, the object being to determine the optimum levels and conditions under which these products might be used.

FISH MEALS AND OILS IN LIVE STOCK FEEDING

Fish Meal

In the field of live stock feeding, fish meal has proven a rich source of nutrients. It is fed particularly for its protein and mineral content, and the percentage of these ingredients determines its value. There are three factors which have retarded the more widespread use of fish meal: First, the rather high price at which it has been sold relative to other feeds; second, the lack of definite information regarding its use; and third, a variability in the product.

The feeding of fish meal has been confined largely to swine, but it has also been used successfully for dairy cattle and in a limited way for other live stock. Growing market animals and milking cows seem best adapted to utilize efficiently this and other high protein feeds combined with carbonaceous grains. Fish meal is relatively more valuable for rapid gains and high production than for maintenance. However, fish meal may be included to advantage in the maintenance ration of breeding animals, but the percentage used should be lower than that normally included in the growing ration.

Protein and minerals are important constituents in any supplemental feed, and these, together, make up to 90 per cent of fish meal. The protein is of very high quality and tests have proven that more than 90 per cent of it can be readily utilized by the animal. Further, the protein of fish meal has a high biological value and contains amino acids essential to good nutrition. The amino acids contained in fish meal closely resemble those in milk—a natural food for growing animals. Thus, on this point, the efficiency of fish meal as a protein supplement is assured. Being of organic origin and containing available calcium and phosphorus, the minerals of fish meal are suitable to supply the requirements of the growing animal. Since fish meal contains approximately 15 to 20 per cent minerals, additional mineral matter is seldom required where it is the chief protein supplement in the ration.

STANDARDS UNDER FEEDING STUFFS ACT

The recently revised standards for fish products, established by regulation under the Feeding Stuffs Act, are as follows:—

"*Fish Meal* shall be the clean, dried, ground residue, containing not more than 6 per cent of oil, from undecomposed whole fish and/or fish cuttings.

"*Oily Fish Meal* shall be the clean, dried, ground residue, containing more than 6 per cent of oil, from undecomposed whole fish and/or fish cuttings.

"*Fish Residue Meal* shall be the clean, dried, undecomposed residue from the manufacture of glue from non-oily fish."

The variability of its oil content is an important factor in the feeding value of fish meal. The high oil content fish meals are generally made from fish other than white fish, and in addition to containing a high percentage of oil, have a decidedly fishy odour. Certain investigators have reported tests where the feeding of fish meal, high in oil, caused an undesirable flavour in the meat.

Added to the above standards for fish products which differentiate on the basis of oil content in fish meal are the following restrictive clauses:—

"Any fish product sold or offered for sale for feeding purposes (*a*) which is designated as to the kind or type of fish employed in its manufacture, shall correspond thereto (*b*) shall be totally free from any solvent (*c*) shall contain not more than 4 per cent of salt (NaCl)."

A "Fish Meal" which was used at the Nappan Experimental Farm, 1930, and which would have qualified under the new standard in the first grade, analyzed as follows:—

*Analysis**

	Per cent
Moisture	7·62
Protein	67·50
Fat	2·48
Ash	22·38

Ash contained 19·71 per cent bone phosphate.

* Analysis by Dr. F. T. Shutt, Dominion Chemist.

This fish meal was made from white or non-oily fish and was yellowish-brown in colour with a characteristic slightly fishy, but not unpleasant odour. This type of fish meal with its high protein and mineral content and low percentage of oil has been fed to live stock with good success.

EXPERIMENTAL

Swine.—From 1924 to 1931 inclusive, a number of experiments were undertaken on representative Dominion Experimental Farms to determine the feeding value of fish meal for growing and fattening swine. At Fredericton, N.B., Lethbridge, Alta., and Agassiz, B.C., fish meal was compared with skim-milk and tankage and at Nappan, N.S., only with skim-milk. The experiments, therefore, not only tested these protein supplements but were carried out under eastern and western feeding conditions.

In allotting the pigs, the attempt was made to eliminate all factors other than feed which would influence the results. The feeding period was started shortly after weaning and continued until the pigs attained market weight.

In Table I, the results of the trials conducted at Fredericton, Lethbridge and Agassiz are summarized.

TABLE I—FISH MEAL vs SKIM-MILK vs TANKAGE

Summary of Results at Fredericton, Lethbridge and Agassiz

Item		Fish meal	Skim-milk	Tankage
Number of trials	No.	6	7	4
Number of pigs	No.	57	68	26
Number of pig days	days	4,935	5,901	2,876
Average number days on test	days	86·6	86·8	110·6
Average initial weight	lb.	65·9	63·0	45·5
Average finished weight	lb.	176·6	182·4	169·9
Total gain	lb.	6,308·5	8,180·0	3,234·5
Average daily gain	lb.	1·278	1·386	1·125
Feeds consumed:				
Grain	lb.	23,765	29,947	12,321
Skim-milk	lb.	.....	43,191	.....
Fish meal	lb.	1,644	.....	.....
Tankage	lb.	.....	.....	1,275
Average daily feed consumption:—				
Grain	lb.	4·82	5·88	4·28
Skim-milk	lb.	.....	8·48	.....
Fish meal	lb.	0·33	.....	.....
Tankage	lb.	.....	.....	0·44
Feed per 100 pounds gain:—				
Grain	lb.	376·7	366·1	380·9
Skim-milk	lb.	.....	528·0	.....
Fish meal	lb.	26·06	.....	.....
Tankage	lb.	.....	.....	39·42
Total dry matter consumed	lb.	22,868·1	31,228·3	12,236·4
Average daily consumption dry matter	lb.	4·63	6·13	4·25
Dry matter per 100 pound gain	lb.	362·50	381·76	378·31

The original data collected in these trials were essentially similar, and therefore, it was possible to summarize the results as shown. Being a summary of a number of trials involving a large number of animals, the necessary significant difference between lots is small. The average daily gains show some differences but these can be directly correlated to the average daily intake of feed. When these differences are levelled, there is little significance in the difference in the average daily gains. It is to be noted that all three supplements promoted reasonably rapid gains.

Considering the feed required per 100 pounds gain, the amount of basal grain used in each lot is practically the same. There is a small difference in favour of the skim-milk lots, but this is within the limits of experimental error. The protein supplement fed per 100 pounds gain shows some variations but these are closely connected with the relative protein content of the supplements.

The total dry matter and the dry matter required per 100 pounds gain are shown in the table in order that the results of the three lots may be more directly comparable. The fish meal lots show a slight but significant advantage over both the skim-milk and tankage lots in the amount of dry matter required per 100 pounds gain.

The trials conducted at the Experimental Farm, Nappan, N.S. compared fish meal and skim-milk as supplements in rations which included green feed and minerals. It was impossible to summarize these properly in the preceding table due to the extra feeds included. The results are, therefore, presented in summary form in Table II.

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TABLE II—FISH MEAL vs SKIM-MILK WITH GREEN FEED AND MINERALS

Summary of Results at Nappan

Item		Fish meal	Skim-milk
Number of trials	No.	5	5
Number of pigs	No.	32	30
Number of pig days	days	4,580	4,310
Average number days on test	days	143·1	143·7
Average initial weight	lb.	27·3	26·0
Average finished weight	lb.	183·8	187·2
Total gain	lb.	5,007·0	4,837·0
Average daily gain	lb.	1·093	1·122
Feeds consumed:—			
Grain	lb.	16,412	15,429
Skim-milk	lb.	.....	21,954
Fish meal	lb.	1,312	.....
Roots	lb.	2,794	2,435
Green feed	lb.	1,716	1,716
Minerals	lb.	616	576
Average daily feed consumption:—			
Grain	lb.	3·58	3·58
Skim-milk	lb.	.....	5·09
Fish meal	lb.	0·286	.....
Roots	lb.	0·610	0·565
Green feed	lb.	0·375	0·398
Minerals	lb.	0·134	0·134
Feed per 100 pounds gain:—			
Grain	lb.	327·8	319·0
Skim-milk	lb.	.....	453·9
Fish meal	lb.	26·2	.....
Total dry matter consumed	lb.	17,276·0	17,308·0
Average daily consumption dry matter	lb.	3·77	4·02
Dry matter per 100 pounds gain	lb.	345·04	357·83

The results at Nappan confirm very definitely those obtained from the three other experimental farms reported in Table I. It is seen that good gains were made in both lots with little difference in the average daily gains. Relatively, the feed per 100 pounds gain corresponds closely with that shown in Table I. So far as the grain required per 100 pounds gain is concerned, slightly less was used in the skim-milk lots. However, when the dry matter consumed per 100 pounds gain is considered—the best standard for comparison—the fish meal lots show a slight but definite advantage.

Dairy Cattle.—Experiments with milking dairy cows were conducted at the Dominion Experimental Farm, Agassiz, B.C., in 1929 and 1932. In these, fish meal and linseed oil meal were compared as protein supplements to the ration. The reversal system of experimentation was followed, using nine cows in the first experiment and ten in the second. Fish meal was included in the meal mixtures at the rates of seven and eleven per cent respectively and the amounts of linseed oil meal so adjusted as to supply an equal percentage of protein.

Considering total milk produced, feed consumed and feed cost to produce 100 pounds milk, the results of the first experiment proved fish meal quite the equal of linseed oil meal. In the second experiment the results showed a small margin in favour of the fish meal lot.

The combined results of these experiments showed that one pound of fish meal replaced two pounds of linseed oil meal with good results.

The products of fish meal feeding were of good quality as evidenced by the following extract from the 1932 report:

"There was no undesirable flavour or odour from the milk at any time during the trial, which same result has been reported from previous tests."

Because proteins from a variety of sources best supply the requirements of animals it is recommended that when fish meal is fed to dairy cattle it be in combination with other protein feeds.

SUMMARY

1. Fed at rates which averaged 6·5 and 7·4 per cent of the concentrate rations during the feeding periods, fish meal proved a suitable supplement for growing and fattening swine.

2. When tested with skim-milk and tankage for swine, fish meal produced comparable gains.

3. Fish meal is an efficient protein supplement for swine as shown by the advantage over skim-milk and tankage in dry matter required per 100 pounds gain.

4. Fish meal may replace skim-milk or tankage in the ration of growing and fattening swine, and its value would seem to be in direct relation to its relative protein content.

5. Fish meal proved as efficient as linseed oil meal in the dairy cattle ration. In the experiments conducted, one pound of fish meal replaced two pounds of linseed oil meal with good results.

6. It is recommended that where fish meal is fed to dairy cattle it be in combination with other protein supplements, but it should not at any time constitute more than 10 to 12 per cent of the total grain ration.

7. The economy of fish meal feeding in comparison with other protein supplements is closely correlated with the relative protein content.

8. Fish meal contains 15 to 20 per cent minerals of high quality; therefore, its inclusion as the chief supplement in the ration generally obviates the necessity of supplying additional mineral matter.

9. The constant feeding of fish meals of high oil content may result in a discrimination against the products of such feeding.

Fish Oils

Of the fish oils, cod liver oil is well known for its health-giving properties. It contains vitamins A and D in liberal yet safe amounts. These are essential and vitamin D is particularly valuable when winter sunshine is at a minimum. For human use and also for small-animal feeding, cod liver oil is considered a valuable supplement to what would otherwise be deficient rations.

Cod liver oil has never attained very great prominence in supplementing the rations of the larger farm animals because the nutrients which it can supply or help to make available can be procured almost equally well and much more cheaply from the ordinary farm live stock feeds plus a minimum of bought supplements such as protein feeds and minerals.

There are some occasions, however, when cod liver oil constitutes a valuable feed for the larger farm animals. Pigs being grown during the winter months sometimes develop an unthrifty rachitic condition resulting from an evident deficiency of some of the vital feed elements. Such animals can often be brought into a more thrifty condition by feeding cod liver oil. If trouble is anticipated small doses of the oil will likely correct any tendency to such rachitic condition.

Cod liver oil, as the name implies, is procured from the livers of codfish. Some lesser known fish oils which are body oils have come into some prominence of late. In particular, pilchard oil has come to the public attention as evidently available in considerable amount and being a carrier of vitamins A and D. However, the biological value of pilchard oil had not been definitely determined and even practical experiments and observations were not available as to its supplemental value in the feeding of live stock. An experiment, as described below, was therefore undertaken to determine the relative values of these fish oils in live stock feeding.

EXPERIMENTATION WITH SWINE

With a considerable amount of knowledge and observations already accumulated on the value of cod liver oil, an experiment was planned to be undertaken on a number of experimental farms and stations throughout Canada to determine the comparative value of cod liver oil and pilchard oil in the ration of growing pigs.

The equipment available and the type of the problem precluded the possibility of a critical study of the vitamin content of the fish oils. However, it was possible in practical experiments to demonstrate the value of the oils through the relative well being and thrift of the pigs as measured by average daily gains, feed consumption per 100 pounds gain, cost per unit gain and net returns for the feeding of oil. The oils were fed generally at the rate of one ounce per pig daily with a few additional lots at the rates of one-half ounce and two ounces of oil per pig daily.

The results of an experiment conducted at Ottawa on the value of cod liver and pilchard oils are given in Table III. This constitutes a typical example of the many experiments conducted on various experimental farms and stations throughout Canada during the past two years.

TABLE III—NUTRITIONAL VALUE OF PILCHARD AND COD LIVER OIL FOR GROWING PIGS

CENTRAL EXPERIMENTAL FARM, OTTAWA

Winter 1931-32

Item		Lot I Check	Lot II Cod liver oil	Lot III Pilchard oil
Number of pigs	No.	6	6	6
Initial weight, gross	lb.	260	255	259
Initial weight, average	lb.	43·3	42·5	43·1
Original value of pigs	$	18·14	17·79	18·07
Final weight, gross	lb.	975	1,099	1,076
Final weight, average	lb.	162·3	183·1	179·3
Total gain	lb.	715	844	817
Average gain per pig	lb.	119·1	140·7	136·1
Number days on test	No.	130	130	130
Average daily gain per pig	lb.	0·92	1·08	1·04
Total meal consumed	lb.	2,605	2,765	2,760
Meal eaten per pound of gain	lb.	3·63	3·27	3·38
Total oil consumed	gal.	.....	5·16	5·42
Total feed cost*	$	32·04	34·01	33·95
Feed cost per head*	$	5·34	5·67	5·66
Feed cost per pound of gain*	$	·045	·040	·042
Cost of cod liver oil at 95 cents per gal	$	.....	4·90	.....
Cost of pilchard oil at 68 cents per gal	$	.....	.....	3·69
Gross returns at $4.60 per cwt	$	44·85	50·55	49·50
Net returns: gross returns minus feed cost and original value hogs and oil	$	— 5·33	— 6·15	— 6·21
Difference in net profit between oil and check lot	$	.....	— ·82	— ·88
What one could afford to pay for oil used and make same margin as Check Lot	$	.....	4·08	2·81
What one could afford to pay for oil per gallon	$	.....	0·79	0·52

* Oil not included.

From a survey of Table III, it will be noted that the additions of oil increased the daily gains somewhat from that of the check lot, and also lowered the cost of gain exclusive of the cost of the oil. However, the added cost of the oils made the two oil lots slightly less profitable than the check lot and as is brought out in the last line of the table, the value of the oils as determined by this experiment is considerably lower than the price at which they were purchased. No mention will here be made on the relative values of the two oils since this question will be taken up later.

As mentioned above, experiments were conducted at a number of experimental farms and Table IV is, therefore, presented showing the essential data from these in summary form.

TABLE IV—RESULTS OF COD LIVER OIL AND PILCHARD OIL EXPERIMENTS WITH GROWING PIGS

DOMINION EXPERIMENTAL FARMS

Winters of 1931-32 and 1932-33

Dominion Experimental Farm or Station	Year conducted	Number of pigs per lot	Average initial weight	Treatment	What one could afford to pay per gallon	
				Oil per pig daily	Cod liver oil	Pilchard oil
		No.	lb.	oz.	$	$
Ottawa	1931–32	6	43	1	0 79	0 52
Agassiz	1931–32	10	44	1	0 73	0 78
Scott	1931–32	10	51	1	0 31	0 79
Kapuskasing	1931–32	7	30	1	0 83	0 41
Ste. Anne de la Pocatiere	1931–32	6	35	1	0 64	0 19
Nappan	1931–32	5	37	1	−0 17	−0 27
Nappan	1931–32	5	38	1	−0 07	0 01
Nappan	1931–32	5	37	2	−0 13	0 06
Agassiz	1932–33	5	40	1	0 02	0 41
Agassiz	1932–33	5	40	½	.....	−0 05
Kapuskasing	1932–33	5	39	1	0 14	0 12
Kapuskasing	1932–33	5	39	½	−0 98	1 06
Scott	1932–33	10	24	1	0 79	1 06
Scott	1933–34	8	51	1	1 08	0 65

The most pertinent observation in the summarized data of Table IV is the inconclusiveness of the results. There is a wide variation in the returns for the oil in the different lots which would seem to indicate that it would be unwise to place too much confidence in them or to attempt to draw very definite conclusions therefrom. The results do indicate, however, that in a majority of the experiments there was some return from the feeding of oil but it was only in isolated cases that it was sufficient to pay the purchase price of the oil. Thus to be useful as swine feeds both cod liver oil and pilchard oil must be priced fairly low. Also it must be noted that in a number of experiments the oil is given a minus value, indicating that not only did the oil make no return for the feeding of same but actually that it increased the cost of gain, thus making these oil-fed lots less economical than the check lots even exclusive of the cost of the oil. Further, the opinion is held that with good feeding practice the addition of oil is not often necessary, it being possible to supply the necessary nutriments more cheaply from other feeds.

Table IV shows a variation in the relative returns from cod liver oil and pilchard oil. However, it is impossible to state which oil is the superior one in the feeding of swine since the results show considerable contradiction and no definite trend.

COOKING TESTS.—After the completion of the feeding trials, the meat from the pigs at two stations was submitted to cooking tests. Some of the pigs were slaughtered and the meat cooked immediately after completion of the oil feeding tests. Others were fed for 30 days without oil and the meat then submitted to the cooking test.

There was a decided fishy taste to all samples of meat slaughtered immediately after oil feeding. In most cases the fishy taste of the meat was so objectionable that it could not be eaten. The fishy flavour was unmistakably present in the lots receiving one-half ounce of cod liver oil or pilchard oil per pig daily as well as those receiving double this amount.

The meat from those pigs fed for 30 days without oil before slaughtering was entirely free from fish flavour. Further it is very probable, although not definitely proven, that the fat of these pigs was considerably firmer than those slaughtered at the conclusion of oil feeding. In the light of these experiments it would, therefore, be wise procedure where one of the fish oils is fed to hogs to finish without oil for 30 days before marketing.

Economy of Oil Feeding.—In the correction of rachitic tendencies and for the optimum development of costly breeding stock, the fish oils are sometimes used in order to promote maximum growth and development and thus obviate any danger of undersize or stunting.

In these cases economy is not the all-important consideration, for the cost of gains, if figured as such, would be rather high. However, the feeder or breeder feels justified and well satisfied, being content to pay relatively higher in order to produce a somewhat superior breeding animal. Were this same system of feeding and management applied to the growing of market animals, it would not prove an economical practice and so would not find general favour.

Rate of Feeding.—There is not any set rule yet established of the optimum amount of cod liver and pilchard oil for animal feeding. In the experiments herein reported, the oils were fed at rates of one-half ounce, one ounce and two ounces per pig daily. The present popular rate of feeding these oils to swine is one ounce per pig daily, and from a scrutiny of these experiments the best rate would seem to be one ounce per pig daily or perhaps even as low as one-half ounce per pig daily.

Conclusions

1. The fish oils improve the rate of gain in growing swine and lower the meal requirement per unit gain.
2. The present price of these oils prohibits their use when economy as in growing market hogs must be considered.
3. Cooking tests indicate that it is necessary to feed market hogs without oil for 30 days before slaughtering to prevent a fishy flavour in the meat.

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The authors wish to express their appreciation of the co-operation of the Superintendents of Dominion Experimental Farms and Stations in undertaking these projects, and in particular to acknowledge the work at Agassiz, B.C., Lethbridge, Alta., Scott, Sask., Kapuskasing, Ont., Ste. Anne de la Pocatière, Que., Fredericton, N.B., and Nappan, N.S.

FISH MEALS AND OILS IN POULTRY FEEDING

The feeding of fish products in any quantities to poultry is of comparatively recent origin. The growth of this phase of poultry nutrition has been fairly rapid, however. In so far as fish oils are concerned their use is entirely dependent upon their vitamin content. They are not fed to poultry as a source of fat. Fish meal, on the other hand, while containing vitamins to some extent, is fed for its value as a source of proteins and minerals. The two fish products under consideration will be dealt with separately.

Fish Meals

Fish meals, in common with other food products, vary considerably in quality according to origin, manufacture and numerous other characteristics all of which have a bearing upon their biological efficiency as food products. A typical fish meal would conform fairly closely to the following range: protein 60 to 70 per cent, fat 3 to 10 per cent, and ash in the neighbourhood of 15 per cent.

A comparison of fish meal with meat meals of the type fed to poultry shows usually from 5 to 10 per cent higher protein for the former, with a similar level of ash and slightly lower fat content. Meat and bone meals may run lower in protein and higher in ash.

Digestibility.—A consideration of actual biological efficiency presupposes a knowledge of the digestibility of these products. Although great difficulty is experienced in the carrying out of digestibility trials with poultry several determinations have been made and amongst these that of Fraps,[1] showing for both meat meal and fish meal a digestibility of 91 per cent for protein and 89·5 per cent and 95·7 per cent for fat respectively. It appears therefore that both products are practically equally digestible with the exception of fat in which respect fish meal is superior.

Protein Quality.—It has been pointed out that fish meals are usually higher in protein and according to one authority equally digestible with meat meal in so far as protein is concerned. In this connection retention of protein by chicks is considered to be an excellent measure of efficiency for feeds of a high protein nature. Such experimental tests are carried on with chicks in order to overcome the factor of egg production. In this connection the work of Wilgus, Norris and Ringrose[2] of Cornell University is cited, in which it was clearly shown that a great variety of fish meals and meat meals fed to chicks showed a decided superiority in protein retention for fish meal over meat meal. The method of preparation of the fish meal (whether flame dried or vacuum dried) had an appreciable influence upon this result, the vacuum dried meals being superior. Thus the proportion of protein consumed which is eliminated with the droppings is higher for meat meal. The actual range of efficiency was from 67 to 82 for meat meals of different protein levels and from 81 to 107 for fish meals prepared in different manners, in comparison to a standard of 100 for casein, a purified protein.

Ash.—Variation in ash content is very great in these products, particularly in meat meal as previously pointed out. While the form in which most of these minerals occur, namely, calcium phosphate (bone meal), is of great value in poultry feeding, a high mineral meat meal means a preponderance of bone and a lower protein level, consequently, the meal ceases to be a high protein concentrate, on which basis it was purchased. Fish meal is normally less variable in mineral content than meat meal.

In considering minerals the iodine content of fish meal should be mentioned. Numerous references indicate fish meal to contain a higher level of iodine than meat products. Orr and Leitch[3] show tables indicating an iodine content of 32 gammas per 100 gms. for fresh pilchard fish with a corresponding content of from 5·5 to 8·9 gammas for fresh beef. Analyses by the Dominion Chemist show actually 170 gammas of iodine per 100 gms. in pilchard fish meal which corresponds to approximately 20 gammas per 100 gms. in meat meal if the fresh beef content above is reduced to a meat meal (dry) basis.

This relationship varies tremendously depending upon the source of the samples considered but owing to the naturally high iodine diet of fish foods (marine plants and animals) fish products are considered to be normally much higher than other animal products in iodine. While the addition of supplements high in iodine has not been yet shown to be necessary to normal functions of fowl there is every reason to believe that under conditions of deficiency of this mineral (goitrous areas) such may be the case. It has been shown that eggs of high iodine content may be produced by feeding iodine supplements to hens which eggs are considered to be more valuable in human nutrition.

Fat.—Contrary to popular conception and due to improved methods of processing and recent legislation the fish meals at present available in Canada are lower in fat than similar meat meals.

The status of fat in poultry nutrition has not been subjected to careful scrutiny in the past and its desirability or otherwise is therefore not definitely known. It is a fact, however, that animal products sufficiently high in oil that sub-ideal conditions of storage will bring about rancidity of the product, are certainly objectionable. For this reason high fat meat meals or fish meals are discriminated against.

Except in instances where processing or handling are unsatisfactory the oil of fish meals usually contains an appreciable amount of vitamins A and D which are usually associated with these oils. Stuart and Charles[4] found a sample of fish meal to contain sufficient D to prevent rickets up to eight weeks of age when fed with a standard ration in the absence of sunlight; growth was inferior however. Maynard, Bender and McCay,[5] found white and menhaden fish meal to be a good source of vitamin A, if dried in vacuo.

Millar and Maynard[6] found 15 per cent higher ash content in bones of chicks receiving fish meal than in the control chicks on a vitamin D free ration. A review of the literature shows fish meals to be decidedly superior in these vitamins. It is doubtful whether flame dried meals contain these vitamins to any appreciable extent if at all. It is no doubt unsafe to rely upon fish meals as an adequate source of these vitamins, however, particularly if the method of processing is not known.

FISH MEAL FOR PRODUCTION OF GROWTH

The amount of reliable data available indicating the comparative merits of the protein of fish meal and other high protein feeds of animal origin is not great. Record and Bethke[7] found that with the exception of flame dried menhaden meal, one sample of shrimp meal and tuna meal, a significantly greater growth was obtained with the numerous fish meals tested than with beef scrap. Asmundson and Biely[8] found no significant difference in growth between chicks fed pilchard or salmon fish meal and those fed dried skim milk at the same protein level. St. John, Carver[9] et al found fish meal to be equally efficient with milk powder for growth production as shown by their previous work, and more efficient than meat meal if compared to the results of Heuser and Norris.[10]

Using rats as experimental animals the protein of fish meal was shown by Daniel and McCollum[11] to be decidedly superior to tankage for growth production.

Although the authentic data available with chicks is very meagre indeed it would appear from the work cited above that fish meal is at least the equal of meat meal, tankage and skim milk powder with a strong suggestion of superiority with regard to growth production.

FISH MEAL FOR THE PRODUCTION OF EGGS

While a great deal of data is available in contrasting fish meal with other sources of animal protein for egg production, much of this work is not sufficiently sound for purposes of comparison. A very satisfactory test was carried out at the Dominion Experimental Station at Morden, Man., using Rhode Island Red pullets over a period of approximately six months duration. The test was repeated each year from 1929 to 1933 inclusive. During 1929 a difference in the protein level of the fish meal and meat meal rations existed while in 1932 an attack of bronchitis was experienced prior to the commencement of the test. These years were dropped from consideration for these reasons. The following table shows the data obtained.

RESULTS WITH RHODE ISLAND REDS AT THE MORDEN STATION*

	Meat meal			Fish meal		
	1930	1931	1933	1930	1931	1933
Number of birds	50	50	52	50	50	50
Number of days in test	177	180	180	180	180	180
Number of bird days	8,859	8,562	7,266	8,944	8,964	7,000
Average body weight at commencement of test lb.	5·20	5·06	5·35	5·70	4·90	5·25
Mortality %	8·0	10·0	7·7	4·0	6·0	16·0
Total egg production	4,366	4,243	3,148	4,437	4,356	3,214
Egg production per bird	87·60	89·10	77·98	89·10	87·45	82·64
Average production per bird (3 years)	.....	85·24	.....	.....	86·77	.....

Examination of the above data indicates that meat meal and fish meal were equally efficient for egg production. Results were sufficiently uniform from year to year that the data may be safely averaged. With 152 and 150 birds per pen respectively any appreciable difference in production could have been accurately measured in this test, the difference occurring, namely, 1·53 eggs per bird, being much too small to be significant. Since the protein level was identical for both pens the only variable between the pens was the source of protein.

The same comparison was made by several other of the experimental stations the data of which were not satisfactory for comparison due to insufficient numbers of birds or incomplete control of environmental factors. The most reliable of this data, however, indicated definitely a similarity in quality for these two protein sources for egg production.

Kaupp, 1927,[12] using a large number of birds found fish meal and meat meal to show no significant difference in egg producing ability. Some other investigators found a similar condition to exist although in many instances owing to improper control of environment and for other reasons the data are of questionable value.

FERTILITY AND HATCHABILITY

While no definite authentic work is available to directly contrast fish meal with other animal protein feeds there are many instances of excellent fertility and hatchability with the use of fish meal.

SUMMARY

To summarize briefly, while the exact status of fish meal with regard to its efficiency in comparison to other feeds of a similar nature is not known, it would appear from the data presented that under most conditions fish meal may be used with safety as a substitute for these products.

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FISH OILS

There exists such a mass of data upon the subject of fish oils for poultry feeding that it would be impossible to review all the material in this publication. By far the greatest proportion of work done to date deals with cod liver oil. It has been very definitely shown in many instances that cod liver oil through its vitamin D content prevents the occurrence of rickets in chicks and permits of normal calcification in the body which is essential for normal growth, egg production and reproduction. Through its vitamin A content it is able to greatly improve growth and to prevent symptoms of vitamin A deficiency which consist mainly in ophthalmia, an eye disorder, and lack of motor control.

In so far as practical poultry conditions are concerned during the period of the year when potent sunlight is not available or roughly from November to April, or at all times with birds not subject to direct sunlight, a supplement containing vitamin D is essential to maintain high production without causing the pullet to draw upon her skeletal structure. Fish oils have up to the present proven most efficient for this purpose. With early hatched chicks or with those kept away from sunlight, fish oils are again necessary to prevent rickets and consequent severe stunting in growth. It has also been demonstrated that poultry have a very high requirement for vitamin A. Since this vitamin is not supplied through sunlight it is required at all times and particularly if fresh green feeds are not continuously available. Fish oils again are the most satisfactory source of this vitamin.

QUALITY OF FISH OILS

As was the case with fish meals there is a large variation in the quality of oils available. The chief characteristics which are of importance in feeding practice are vitamin content, rancidity and free fatty acid content. Vitamin content varies from practically none to high potency and oils which are high in one vitamin are often low in the other. Up to the present time the only accurate method of determining potency in vitamins is by the biological test. Briefly, a representative sample of a quantity of fish oil is taken and fed to chicks or rats, preferably the former for poultry work, which are upon a ration devoid of the vitamin to be tested. For vitamin D, the oil has to produce chicks which, upon examination of the bone by chemical tests at six or eight weeks show normal skeletal development. For vitamin A, rate of growth and freedom from " A " deficiency symptoms previously mentioned are taken as the indices of vitamin A content. Oil so tested is, of course, more expensive but is definitely known to be satisfactory for the purpose for which it is intended.

Although it was at one time thought that high free fatty acid content was undesirable it has not been shown that such is the case. Oils of poor physical quality made from stale or rotted livers usually are high in fatty acids and for this reason oils of such content are discriminated against.

Rancidity is fairly common in the very poor quality oils and such an oil should not be fed under any conditions.

Fish oils of many types and from many species have been used in the past few years. Of these, cod liver oils and pilchard oils are the only ones produced in Canada in any quantity at the present time, the former on the Atlantic and the latter on the Pacific Coast. The last mentioned oil has been available for a short time only and little is known of its qualities. The following data is therefore given as an indication of the quality of this product.

PILCHARD OIL

Vitamin D Value.—Since vitamin D is normally less plentiful in natural poultry feeds than vitamin A, and since, as a consequence, vitamin D deficiency symptoms (rickets) are much more prevalent under conditions of confinement than those of vitamin A deficiency, this vitamin was dealt with first. The partial or complete absence of vitamin D from the chicks' ration causes faulty bone formation, and in extreme cases, rickets. Cross-bred White Leghorn male X Barred Rock female chicks were used and were separated into groups of cockerels and pullets only, at time of hatch in the manner described by Warren.* These were divided into pens of twenty-one chicks, each receiving the following treatment:—

Cockerels

Pen 1—Direct sunlight.
Pen 3—No sunlight or substitute.

Pullets

Pen 2—Direct sunlight.
Pen 4—No sunlight—1 per cent pilchard oil No. 2.
Pen 6—No sunlight—1 per cent cod liver oil.
Pen 8—No sunlight—2 per cent pilchard oil No. 1.
Pen 10—No sunlight—2 per cent pilchard oil No. 2.
Pen 12—No sunlight—2 per cent cod liver oil.

Where direct sunlight is referred to, the treatment consisted of permitting the direct rays of the sun to enter the pen through an open window. During the course of the experiment from April 10 to May 22, 1931 (6 weeks) sunlight entered the pens for a total of 226·5 hours or 6·47 hours daily on the average. Where treatment is indicated as no sunlight or substitute, all sunlight was excluded by placing heavy brown wrapping paper over the windows, daylight alone entering by north windows through glass.

The pilchard oil used was of two qualities, No. 1 which represents pilchard oil extracted with the greatest care and handled in such a way as to insure the least possible destruction of vitamins, and No. 2 which represents the ordinary commercial run of oil as produced at rendering plants upon the coast of British Columbia. The cod liver oil used was a Newfoundland poultry oil, which had been proved to be of high potency by previous work at this Division.

The free fatty acidity of these oils expressed as oleic acid was 2·19, 0·60 and 0·89 per cent for cod liver oil and pilchard oils 1 and 2 in the order named. High free fatty acidity is considered to be an undesirable characteristic in fish oils for feeding purposes.

The following all-mash ration was given to all pens: Shorts, middlings, yellow corn meal, and ground oat groats 22 per cent of each; meat meal 6 per cent, fish meal, buttermilk powder and bone meal, 2 per cent of each. This mash showed an analysis as follows: Water, 10·57 per cent; ash, 5·95 per cent; fibre, 3·14 per cent; protein 18·27 per cent; carbohydrates, 55·28 per cent; fat, 7·31 per cent.

Oyster shell was available ad. lib. but no green feed was given during the experiment. All oils used were incorporated into the mash for each pen at time of mixing just prior to the commencement of the experiment.

Weighings of all pens were made weekly and mortality noted to actual date so that calculation of feed consumption could be made upon a bird day basis. All dead birds were autopsied in the pathological laboratory for cause of death.

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* Warren, D. C. Crossbred Poultry. Kansas Agric. Exp. Station Bul. No 252, 1930.

At the close of the experiment, two birds, representative of the pen in so far as could be judged by external characteristics, were removed from each pen, the tibia-fibula bones of the right limb of each dissected out and forwarded to the Division of Chemistry for ash analysis.

The following table shows the data obtained, calculated upon a per bird per day basis (to six weeks of age):—

Pen No.	Treatment	Average weight	Feed consumed	*2Ash content of bones (actual)	*2Ash content of bones
		grams	grams	%	%
*1	Direct sunlight	372·4	1,032·6	16·07	92·04
2	Direct sunlight	307·4	1,036·3	16·24	93·01
*3	No sunlight or substitute	192·2	698·0	9·88	55·59
4	No sunlight—1 p.c. pilchard oil No. 2	342·5	1,036·8	17·46	100·0
6	No sunlight—1 p.c. cod liver oil	349·6	1,097·2	17·07	97·77
8	No sunlight—2 p.c. pilchard oil No. 1	305·1	948·7	14·11	80·81
10	No sunlight—2 p.c. pilchard oil No. 2	294·6	916·1	16·29	93·30
12	No sunlight—2 p.c. cod liver oil	306·5	831·3	17·05	97·65

* Cockerels.
*2 Expressed as percentage of the highest ash content (pen 4).

It will be noted by the above table that pens of cockerels upon direct sunlight and no sunlight or substitute were used as controls. In the case of the latter, it was not found possible to duplicate this pen with pullets and in the former case this pen must be substituted for the pullet pen upon direct sunlight, in so far as is possible, owing to the fact that the low temperature and resultant draught experienced kept the pullets away from the windows and the sunlight during the first part of the experiment, whereas the cockerels, owing to the nature of the ventilation of the building, were not under this handicap.

In considering the results from the pullet pens it will be noticed that the positive control upon direct sunlight must be eliminated from the consideration for reasons just mentioned. After making due allowance for the greater weight expected of cockerels the direct sunlight pen in that group may be compared to the pullet pens. Since figures from upwards of 800 birds covering a period of seven years indicate that pullet weight in White Leghorns is approximately 87·8 per cent of cockerel weight at eight weeks of age* it may be safely determined that a fairly similar condition would exist under the conditions of this experiment. This would give a weight closely comparable to the 1 per cent pilchard oil and 1 per cent cod liver oil pens among the pullets—326 grams to be exact. It is apparent then, from the data obtained, that no significant difference in growth produced exists between sunlight, 1 per cent pilchard oil No. 2 and 1 per cent of cod liver oil. While the pens receiving 2 per cent of these oils did not attain so great a weight it is doubtful if the differences between any of these pens are in any way significant. In comparison with the unsupplemented ration, the birds upon which received neither sunlight nor substitute, all the additions to the rations of the pullet pens gave superior results.

Without doubt the most positive indication of the efficiency of these supplements, in so far as vitamin D is concerned, is the percentage ash content of the chick bones analysed. It will be noted from a consideration of the table that in no instance is there a significant difference in the ash content of bones except for the pen with "no sunlight or substitute."

It is apparent from the data that, in the case of the pullet pens, there is no significant difference in the ash content of any pen with the possible exception of the 2 per cent pilchard oil No. 1, showing only 80·1 per cent of the ash of

* Waters, N. F. Inheritance of Body Weight in Domestic Fowl, Agr. Exp. Station, Rhode Island, Bul. 228, 1931.

the best pen. All pens are, however, significantly higher than the control pen "no sunlight or substitute" with only 55·59 per cent of the ash content of the best pen.

Rickets was experienced in the "no sunlight or substitute" pen at four weeks of age and at five weeks was quite advanced. The presence of this condition is reflected in the low ash content of the bones of the chicks of this pen (9·88 per cent).

It is also apparent from the data that the extra care in refining which was given to the sample pilchard oil No. 1 had no beneficial effect upon its growth producing or ash depositing value, but seemingly had the reverse effect.

Since this project was only of sufficient duration to ascertain whether prevention of rickets and normal growth would be obtained during the starter period, the pen upon 1 per cent of pilchard oil No. 2 was carried to sixteen weeks of age under the same treatment and in close confinement. Growth was entirely normal and the pullets were in excellent condition throughout.

Pilchard oil is evidently an excellent source of vitamin D since rickets was prevented in all cases in this experiment when fed at levels similar to those at which cod liver oil is ordinarily fed. It must be borne in mind, however, that no attempt was made to feed a ration completely deficient in vitamin D but merely one sufficiently low to induce rickets in the absence of sunlight or some substitute. The ration used has previously produced rickets at this division when unsupplemented. As a consequence, where rations are fed which are known or suspected to be considerably more deficient in this vitamin than the ration used in this experiment, it is quite possible that a greater percentage of oil may be necessary.

In order to obtain confirmatory data the project was duplicated in part upon the Experimental Farm at Nappan, N.S., and the Experimental station at La Ferme, P.Q. Results obtained upon both farms substantiate the findings above reported, in growth, condition, and bone analyses. Consequently the detail of these projects will not be reported herein, but may be obtained from the farm or station concerned. It is sufficient to point out that the confirmation obtained under such varying conditions of climate adds appreciably to the value of the results obtained at Ottawa.

Summary.—(1) It has been demonstrated that the addition of pilchard oil to the rations used in this experiment at the rate of 1 per cent of the total feed consumed prevented the occurrence of rickets and produced normal bone development. The pilchard oil and cod liver oil used were of equal efficiency in this test. It is concluded, therefore, that when pilchard oil similar in quality to that used herein is available, it may be substituted for cod liver oil for this purpose.

(2) Carefully refined pilchard oil proved to be no more efficient in supplying vitamin D than the general run of oil.

Vitamin A Value.—The function of vitamin A of which some fish oils are an excellent source, is mainly in the production of growth. A deficiency of this vitamin may also cause a diseased condition of the eyes, known as ophthalmia. Since this vitamin is essential to normal maintenance and development in chicks, the vitamin A value of pilchard oil was the subject of the test herein reported.

Barred Plymouth Rock chicks were used in this test, being divided as evenly as possible into six pens of twenty-four chicks each. They were kept in a battery brooder in which all external conditions were readily controllable so that treatment could be made identical for all pens.

The treatment accorded the pens was as follows:—

Pen No.	Ration	Supplement	Daily irradiation
1	Basal	1 p.c. pilchard oil	Ten minutes.
2	Basal	1 p.c. cod liver oil	Ten minutes.
3	Basal	No supplement (control pen)	Twenty minutes.
4	Basal	2 p.c. pilchard oil	Ten minutes.
5	Basal	2 p.c. cod liver oil	Ten minutes.
6	Standard	1 p.c. cod liver oil	Ten minutes.

The basal ration fed was considered to be vitamin A free or approximately so and was composed of the following ingredients: Bran, 15 per cent, wheat middlings, 30 per cent, ground oats, 28 per cent, white corn meal, 10 per cent, bone meal, 2 per cent and skim milk powder, 15 per cent.

At two weeks of age 30 per cent of ground oat groats was added to this ration since the consistency of the ration due apparently to its high fibre content and the fineness of the skim milk powder upset the digestion of the birds. They returned to normal immediately this change was made and before growth was seriously retarded.

The standard ration as given to pen 6 was one which had previously given excellent growth under identical conditions and was as follows: Wheat shorts, wheat middlings, yellow corn meal and ground oat groats 22 per cent of each, meat meal, 6 per cent, fish meal, buttermilk powder and bone meal, 2 per cent of each. To this mixture 1 per cent of poultry cod liver oil was added. The analyses of these rations were as follows:—

*Ration	Moisture	Crude protein	Fat	Carbo-hydrates	Fibre	Ash
	%	%	%	%	%	%
Basal	6·93	18·07	5·83	59·61	4·93	4·63
Standard	6·44	19·56	7·55	53·79	5·13	5·53

* All analyses courtesy of the Division of Chemistry of this Farm.

The analysis of the standard ration showed originally only 3·14 per cent of fibre but was made equal to that of the basal ration by the addition of high grade pure paper pulp.

One mixing only of the basal and standard ration was made so that each pen received the same mixture throughout the test. No grain or green feed was fed at any time but limestone grit was scattered over the mash occasionally.

Since it was highly desirable that the variation in the level of vitamin D of these oils should have no effect upon the results, the chicks of all pens were irradiated daily with the mercury vapour lamp at a distance of three feet from the subjects. Since it was previously shown that both the cod liver oil and pilchard oil were well supplied with vitamin D it was considered that ten minutes daily was sufficient for the pens using these supplements as against twenty minutes, the most normal period of irradiation to produce normal bone formation as indicated by previous work at this Division, for the control pen which received no oil.

The experiment covered a period of seven weeks with a short additional period for a curative test upon birds suffering from vitamin deficiency.

The oils used were similar in source to those of the vitamin D experiment, but no refined pilchard oil was used. The free fatty acidity was 3·69 per cent and 0·66 per cent for the cod liver oil and pilchard oil respectively.

The following table shows the data obtained upon a per bird per day basis:—

Pen No.	Ration	Supplement	Daily irradiation	(4 weeks) Average weight	(7 weeks) Average weight	Feed consumed
			minutes	grams	grams	grams
1	Basal	1 p.c. pilchard oil	10	190·1	426·0	1,259·0
2	Basal	1 p.c. cod liver oil	10	183·4	395·4	1,129·2
3	Basal	No supplement	20	118·3	.....	.....
4	Basal	2 p.c. pilchard oil	10	192·4	421·5	1,164·1
5	Basal	2 p.c. cod liver oil	10	168·9	374·3	1,074·2
6	Standard	1 p.c. cod liver oil	10	235·9	516·4	1,393·3

The pullet weight of all pens, excepting pen 3, was found to be 92 per cent of cockerel weight at seven weeks of age. The average weight per bird at seven weeks as shown by the above table represents the average weight for the pen expressed as " pullet weight."

As will be noted from the above table, weight attained was greatest by the birds upon pilchard oil in every instance, although the differences between pilchard oil and cod liver oil in this respect are of doubtful significance. The birds upon the standard ration plus 1 per cent of cod liver oil, however, made significantly greater gains than did all others in the test.

The chicks of pen 3 receiving the vitamin A free ration only, lost ground rapidly after the second week. At three weeks of age some individuals showed a staggering gait in walking, and in some instances complete loss of balance. At four weeks of age the pen had to be removed from the test to avoid total mortality. It was apparent from these results that the basal ration was vitamin A free or approximately so.

It will also be noted that feed consumption varied fairly closely in proportion to the growth attained.

In considering the data recorded it is apparent that when a ration very low in or devoid of vitamin A was fed to chicks cessation of growth and extreme deficiency symptoms resulted. The addition of cod liver oil or pilchard oil to such a ration increased growth and prevented the appearance of such symptoms.

SUMMARY.—1. The addition of pilchard oil or cod liver oil to a ration otherwise deficient in vitamin A increased growth and prevented the development of deficiency symptoms in chicks.

2. Neither pilchard oil nor cod liver oil, however, when fed with this deficient ration at levels of 1 per cent and 2 per cent of the total feed consumed brought about as rapid growth as was attained by a pen upon a well-balanced ration.

3. It would appear from the data obtained that pilchard oil and cod liver oil were of equal value in so far as vitamin A content is concerned with a suggestion that pilchard oil was slightly more efficient in this respect.

GENERAL CONCLUSIONS

In consideration of the data above reported it would appear that pilchard oil is a good source of both vitamins A and D. The results obtained from the very representative samples used indicate that pilchard oil of good quality may be substituted for cod liver oil in the feeding of young chicks. Since there is apparently little if anything to choose between these products in so far as efficiency is concerned, the availability and cost of these oils to the poultryman will be the deciding factors in determining the purchase of one or the other under ordinary conditions.

It is a known fact that where cod liver oils are not biologically tested and standardized much variation in the vitamin value of different oils occurs. While evidence to indicate the extent to which this variation occurs in pilchard oil is lacking in the literature the possibility of its occurrence must not be overlooked when non-biologically tested oils are under consideration.

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FISH MEALS AND OILS IN FOX FEEDING

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During the last six years a great deal of experimental work has been done with cod liver oil in the feeding of silver foxes in captivity. The results to date indicate that cod liver oil is not conducive to favourable results when fed either to adult foxes or to pups during the summer and fall months. There is conclusive evidence that when used it should be fed to the foxes during the breeding season.

During 1932, pups from practically all the females on various experiments showed evidence of rickets during the suckling period. During the winter and spring of 1933, the vixens were fed cod liver oil; the pups from these vixens at two months of age showed no signs of rickets and at the same age the pups weighed from one to one and one-quarter pounds more than those from the same parents the previous year, when the females had not received cod liver oil during the gestation period.

There are indications that female foxes fed cod liver oil throughout the year and particularly throughout the breeding season, although showing pronounced indications of coming in heat, never actually did come in heat and failed to become pregnant. There yet remains to be done a great deal of investigational work on the problem of cod liver oil and other fish oils in relationship to the cover coat when fed during the spring and summer months and the influence on pregnancy when fed during the breeding season. It is evident, however, from the work to date that cod liver oil is useful in ricket control.

Fish meals have not been used in systematic experimental work on the Experimental Fox Ranch at Summerside, P.E.I., although high class edible fish meals have been fed in small quantities without causing digestive disturbances and obviously were a useful source of animal protein in the ration. It is our opinion that fish meals in fox feeding should be high grade fish meals and relatively low in fat content.

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